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| FORM PTO 1390 (REV 12-95) | | US DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE | | ATTORNEY DOCKET NUMBER 35/101053 | |
| TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 USC §371 | | | | U.S. APPLICATION NO. 09/308562 | |
| International Application No. PCT/NO98/00051 | | International Filing Date February 20, 1998 | | Priority Date Claimed February 20, 1997 | |
| Title of Invention MULTIAUTOCLAVE FOR COMBINATORIAL SYNTHESIS OF ZEOLITES AND OTHER MATERIALS | | | | | |
| Applicant(s) For DO/EO/US Rune WENDELBO, Duncan AKPORIAYE, Arne KARLSSON and Ivar Martin DAHL | | | | | |
| Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information: | | | | | |
| 1. <input checked="" type="checkbox"/> This is a FIRST submission of items concerning a filing under 35 USC §371. 2. <input type="checkbox"/> This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 USC §371. 3. <input checked="" type="checkbox"/> This express request to begin national examination procedures (35 USC §371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 USC §371(b) and PCT Articles 22 and 39(1). 4. <input checked="" type="checkbox"/> A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date. 5. <input checked="" type="checkbox"/> A copy of the International Application as filed (35 USC §371(c)(2)) a. <input type="checkbox"/> is transmitted herewith (required only if not transmitted by the International Bureau). b. <input checked="" type="checkbox"/> has been transmitted by the International Bureau. Attachment A: Form PCT/IB/308 c. <input type="checkbox"/> is not required, as the application was filed in the United States Receiving Office (RO/US) 6. <input type="checkbox"/> A translation of the International Application into English (35 USC §371(c)(2)). 7. <input type="checkbox"/> Amendments to the claims of the International Application under PCT Article 19 (35 USC §371(c)(3)). a. <input type="checkbox"/> are transmitted herewith (required only if not transmitted by the International Bureau). b. <input type="checkbox"/> have been transmitted by the International Bureau. c. <input type="checkbox"/> have not been made; however, the time limit for making such amendments has NOT expired. d. <input type="checkbox"/> have not been made and will not be made. 8. <input type="checkbox"/> A translation of the amendments to the claims under PCT Article 19 (35 USC §371(c)(3)). 9. <input type="checkbox"/> An oath or declaration of the inventor(s) (35 USC §371(c)(4)). 10. <input checked="" type="checkbox"/> A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 USC §371(c)(5)). | | | | | |
| Items 11. to 16. below concern other document(s) or information included: | | | | | |
| 11. <input type="checkbox"/> An Information Disclosure Statement under 37 CFR 1.97 and 1.98. 12. <input type="checkbox"/> An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included. 13. <input type="checkbox"/> A FIRST preliminary amendment. <input type="checkbox"/> A SECOND or SUBSEQUENT preliminary amendment. 14. <input type="checkbox"/> A substitute specification. 15. <input type="checkbox"/> A change of power of attorney and/or address letter. 16. <input checked="" type="checkbox"/> Other items or information: Attachment B: Title page of published International application (WO 98/36826) with attached International Search Report (in English); Attachment C: International Preliminary Examination Report with Form PCT/IPEA/416 and amended sheets including claims 1-17; and Drawings for Figs. 1-6. | | | | | |

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| U.S. APPLICATION NO. 09/308562 (U.S. 37 CFR 1.5) | | INTERNATIONAL APPLICATION NO. PCT/NO98/00051 | | ATTORNEY'S DOCKET NO. 35/101053 | |
| 17. [X] The following fees are submitted | | | | CALCULATIONS | PTO USE ONLY |
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| BASIC NATIONAL FEE (37 CFR 1.492(a)(1)-(5)): <input type="checkbox"/> Search Report has been prepared by the EPO or JPO \$840.00 <input type="checkbox"/> International preliminary examination fee paid to U.S. PTO (37 CFR 1.492) \$670.00 <input type="checkbox"/> No international preliminary examination fee paid to U.S. PTO (37 CFR 1.492) but international search fee paid to U.S. PTO (37 CFR 1.445(a)(2)) \$760.00 <input checked="" type="checkbox"/> Neither international preliminary examination fee (37 CFR 1.492) nor international search fee (37 CFR 1.445(a)(2)) paid to U.S. PTO \$970.00 <input type="checkbox"/> International preliminary examination fee paid to U.S. PTO (37 CFR 1.492) and all claims satisfied provisions of PCT Article 33(2)-33(4) \$ 96.00 ENTER APPROPRIATE BASIC FEE AMOUNT = | | | | \$970.00 | |
| Surcharge of \$130.00 for furnishing the oath or declaration later than [] 20 [] 30 months from the earliest claimed priority date (37 CFR 1.492(e)). | | | | \$ | |
| Claims | Number Filed | Number Extra | Rate | | |
| Total Claims | 17 - 20 = | 0 | x \$18.00 | \$ | |
| Independent Claims | 1 - 3 = | 0 | x \$78.00 | \$ | |
| Multiple dependent claim(s) (if applicable) | | | + \$260.00 | \$ | |
| TOTAL OF ABOVE CALCULATIONS = | | | | \$970.00 | |
| Reduction by 1/2 for filing by small entity, if applicable. Verified Small Entity Statement must also be filed. (Note 37 CFR 1.9, 1.27, 1.28) | | | | \$ | |
| SUBTOTAL = | | | | \$970.00 | |
| Processing fee of \$130.00 for furnishing the English translation later than [] 20 [] 30 months from the earliest claimed priority date (37 CFR 1.492(f)). | | | | \$ | |
| TOTAL NATIONAL FEE = | | | | \$970.00 | |
| Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). \$40 per property + | | | | \$ | |
| TOTAL FEES ENCLOSED = | | | | \$970.00 | |
| | | | | Amount to be: refunded | \$ |
| | | | | charged | \$ |

a. ☒ A check in the amount of \$970.00 to cover the above fees is enclosed. (CHECK # 33415)

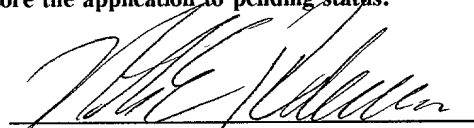
b. ☐ Please charge my Deposit Account No. 23-0975 in the amount of \$_____ to cover the above fees.
A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 23-0975. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

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MULTIAUTOCLAVE FOR COMBINATORIAL SYNTHESIS OF ZEOLITES AND
OTHER MATERIALS

FIELD OF THE INVENTION

- 5 The present invention relates to a pressure and temperature reactor vessel, especially a multiautoclave and to details concerning the design of this equipment.

BACKGROUND OF THE INVENTION

- 10 Many materials, such as e.g. zeolites, are prepared by so-called hydrothermal synthesis at temperatures ranging from 100°C to 200°C requiring crystallization times of 1 hour or more. For syntheses being carried out at temperatures that are higher than the solvent's boiling point, it is necessary to use pressure vessels, and these have to be suitable for the temperature and pressure used during the operation. The pressure vessel has to be designed so that the handling of it does not represent any unnecessary hazard, provided it is used according to working instructions.

- 15 Zeolite syntheses are usually performed in strongly alkaline media, often at pH>14, and the reaction mixture will often contain toxic chemicals, such as e.g. fluoride. Conventionally, syntheses that may be performed at temperatures lower than 110°C are carried out in polymer bottles, often Teflon, while reactions at higher temperatures require steel autoclaves, perhaps lined with Teflon. The price of an autoclave of this type with the required safety details are typically of the order of NOK 10.000,- or higher. Furthermore, such an autoclave will weigh from 1 kilogram and upwards, and all these elements represent limitations regarding the number of syntheses that may be performed in most laboratories in the course of one year.

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Zeolite synthesis is often carried out by keeping the synthesis mixture at around 100°C for at least 6 h. At these moderate temperatures sealed chambers are necessary in order to avoid drying out of the synthesis mixture.

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As an example of conventional zeolite synthesis, Zeolite Y can be prepared according to US 3,130,007, Example 1, by dissolving 5 g sodium aluminate containing 30 weight percent Na₂O and 44 weight percent Al₂O₃ and 22 g sodium hydroxide containing 77.5 weight percent Na₂O in 89,5 ml distilled water. This solution was added to 124.2 g of an aqueous colloidal silica sol with 29.5 weight percent SiO₂, so that the resulting mixture had a composition corresponding to 13.9 Na₂O : Al₂O₃ : 28.2 SiO₂ : 471 H₂O, and the mixture was homogenized by stirring. The mixture was enclosed in a sealed glass vessel, placed in a water bath and heated at 100°C for 21 hours, after which the product was recovered by filtering, washed and dried. Common to all the synthesis procedures

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mentioned and for all other known synthesis procedures for preparation of zeolites on laboratory scale with the purpose of discovering new zeolites or to optimize existing zeolites, is that these are performed in a cumbersome and expensive manner by having to separately prepare each reaction mixture, which typically consists of 4-7 reagents, and by adding the reagents one by one.

In many other examples the synthesis of zeolites and other molsieves needs temperatures well above 100°C, so that steel pressure vessels or the like are required.

Furthermore, each reaction mixture is typically prepared in batches of 5 to 100 g and crystallized in expensive and heavy autoclaves with internal volumes often in the range of 25 to 250 ml and with weights of up to 8 kg per autoclave, causing considerable expense due to a large consumption of often expensive reagents and due to the fact that the handling of the heavy autoclaves often makes it impossible to handle more than one autoclave at the time, and finally that the size of the autoclaves limits the number of autoclaves that may be placed in each oven or heating unit. The combination of all these elements are, according to known technology, making each zeolite synthesis a very resource intensive process, and there is a great need for greater efficiency, rationalization, downscaling and automation. Simple calculations have shown that by combining the different variables which are involved in zeolite synthesis with narrow enough intervals in reagent concentrations, temperatures, reaction time, etc. to cover any phase formation based on known examples, it is feasible to make up 10^{18} recipes. With to-day's synthesis capacity, which on a global basis hardly exceeds 100.000 syntheses per annum, it would take 10.000.000.000.000 years to carry out all these syntheses in which each and every one in theory has potential for the preparation of a new zeolite or other microporous material. The expenses involved in performing these syntheses according to known technology would obviously be formidable, and there is thus a great need for new and more cost efficient methods for zeolite synthesis.

In recent years new, automated methods for systematic preparation of new compounds, so-called "combinatorial techniques", have been developed, but equipment which may be used for liquid phase synthesis at temperatures above approx. 100°C has till now not been disclosed, because this requires that the synthesis takes place in a hermetically sealed vessel at elevated pressures. WO 95/12608-A1 for instance, discloses an apparatus and a method for a) synthesis of several molecules on substrates, comprising distribution of the substrates in the reaction chambers, b) combination of the first addition of these molecules with different reagents in each of the reaction chambers, c) moving the substrates through tubing to separate mixing chambers where the substrates are mixed, d)

redistribution of the substrates by transport through tubing back to the reaction chambers, and e) combination of a second portion of different composition to the first portions of molecules in the different reaction chambers in order to prepare new mixtures. This publication describes only a system for mixing and distribution of different molecules and not a system for hermetical sealing of the reaction chambers which would make it possible to operate at high temperatures, and this system would thus not be suitable for the synthesis of zeolites. In WO 96/11878 there is a description of extensive use of a combinatorial arrangement for synthesis of new materials, including zeolite synthesis at 100°C. Even though this patent application presents a detailed description of instrumentation and equipment developed for different purposes, autoclave systems required for performing the syntheses under the prevailing physical conditions (elevated pressure and temperatures exceeding 100°C) are not described.

Prior art teaches autoclaves with several chambers for special purposes, and there is for instance in US 5.505.916 a description of a metal cassette which can be opened and closed like a suitcase, and which has an interior with compartments intended for placement of the different instruments used by dentists, where these may be sterilized by autoclaving. Furthermore, large autoclaves intended for instance for the growth of crystals, are known, examples are described in US 5.322.591, US 5.312.506 and US 5.476.635, but the purpose of these and similar autoclaves is to make it possible to carry out large-scale syntheses, for which there is a great need when a synthetic procedure has been established and scale-up is desired, or when the purpose is to grow single crystals as large as possible. The autoclave described in the earlier mentioned US 5.312.506 is designed to withstand temperatures up to 1500°C for growth of crystals from metal melts. Another feature in connection with work with autoclaves is energy savings, and this is addressed in EP 0.434.890 A1, with description of a system for insulation of the autoclave walls and for the design of such insulating layers in the walls, which could be useful for large-scale autoclaving, but is of no relevance when working with small laboratory autoclaves which are heated in ovens.

Furthermore, there is a series of known equipment intended for synthesis of proteins and biopolymers, where the design comprises sheets with a large number of chambers intended for screening of syntheses and crystal growth, in its simplest form as described in US 5.096.676. US 5.400.741 describes a diffusion cell for growth of the largest and the most perfect crystals possible of macromolecular compounds by a technique called the "hanging drop" technique. Several patents, e.g. US 5.013.531, US 5.531.185, US 5.362.325 and EPA 0.553.539 A1, deal with cells for growth of proteins and biopolymer crystals in spacecrafts. Common for the latter patents is that the designs described are

very sophisticated and thus very expensive, because they are intended for use in spacecrafts. Common for all equipment designed for synthesis and crystal growth of proteins and biopolymers is that they are meant for use at low temperatures, or typically temperatures in the range of 0°C to 65°C, and that they consequently are not designed to withstand conditions typical for hydrothermal synthesis. In addition, many of these prior art synthesis cells are not lined with Teflon or other similarly inert materials, something that almost without exceptions is required for synthesis of zeolites and the like. There is, e.g., a known design called "multiblock" (Kretnak, V., Vagner, J.; Peptide Res. 3, 182 (1990)) consisting of i) a Teflon block holding 42 reactors, polypropylene syringes equipped with polymer filters, ii) a vacuum adapter connecting each reactor to a vacuum line (not described in detail) which enables rapid washing in an apparatus for continuous flow, iii) two Teflon plates with 42 stoppers to which the Teflon block is fastened during use, and iv) a glass cover used during homogenization. The problem with this design is that the reactors which are made of glass and which do not have protected sidewalls may be used only at low pressures and not in strongly alkaline solutions. There is thus no available literature describing equipment that might be used for practical work with combinatorial zeolite synthesis, in as much as such syntheses almost without exception require hydrothermal treatment of a solution or gel with relatively high content of water and often high contents of organic compounds in a closed chamber, and almost all methods for preparation of zeolites known so far require such conditions during synthesis, and this is true without exception for all methods which have proved to be commercially applicable. The synthesis of zeolites is thus normally performed under hydrothermal conditions which require elevated pressures and high temperatures in periods up to several weeks without leakage. The problem has so far been the costs involved in this type of work, estimated to an average of NOK 5.000,- per synthesis, including recovery of the product and XRD analysis. An important feature when dealing with large series of syntheses is therefore how the product can be recovered and washed in a rational way without insurmountable expense, something that is not disclosed in prior art. As far as known, this type of work is performed in the same manner by all synthesis laboratories engaged in synthesis of zeolites and non-carbon-based molecular sieves.

One objective of the present invention has been to develop a complete system for screening of synthesis conditions for preparation of zeolites and other non-carbon materials requiring hydrothermal conditions in the temperature range 100°C to 250°C in a more cost efficient manner, and it has thus been of interest to improve a series of parameters, which means making them more cost efficient. Some of these parameters are:

1. Reduced size of the separate reaction chambers and increased number of reaction chambers what is called a multiautoclave.

This will lead to reduced use of reactants and thus cheaper synthesis.

2. Automated addition of reactants, for instance by having 100 reaction chambers present in one multiautoclave and by enabling this to be connected to a pipetting machine which makes quick and exact addition of all liquid reactants possible.
3. Simple and easy-to-use mechanism for the closing and opening of the multiautoclave.
4. Simple recovery and washing of the synthesis product and simple cleaning of the multiautoclave after use.
5. Devices allowing automated analysis with X-ray diffraction and automatic identification of known crystalline phases by combination of an automatic sample switcher, a structure library stored in a database and software that can monitor sample switching and identification.

Another objective of the present invention described here has been to design automated equipment for larger synthesis series and prepare formulations based on mixtures of different liquids/solutions with varying reactant ratios.

These and other objectives are attained by the present invention, which represents a breakthrough in terms of cost reduction for e.g. zeolite synthesis in that the reaction mixture crystallizes in a volume reduced typically to 1/100 of what has been used conventional, thereby achieving reduced consumption of reactants and cheaper syntheses, and further by enabling automated addition of reactants, e.g. by having 100 or more available reaction chambers in one single multiautoclave, and that the multiautoclave plates can be connected to a pipetting machine that makes quick and exact addition of all liquid reactants possible, and by being able to place several such plates with reaction chambers on top of each other without difficulty. Furthermore, an important feature of the present invention is the simple and not very time-consuming operation of the multiautoclave.

The present invention relates to a pressure and temperature reactor vessel comprising

- a) a central block having a multitude of perforations, wherein said perforations are through-going perforations, or cavities or other form of holes permanently closed at one end,
- b) cover means, operatively associated with a sealing means, for engagement with said central block to seal the open ends of said perforations forming a multitude of chambers,
- c) a sealing means, operatively associated with the covers means, to form a pressure tight seal when said cover means is brought into position by a locking means,
- d) a locking means acting in concert with the cover means to engage the sealing means so as to define a multitude of reaction chambers.

Applications for the present invention may, in addition to zeolite synthesis, be in any field of activities within research and development connected to products where at least one production-step comprises the mixing of different liquids, e.g. in the fields of organic and inorganic syntheses, paint production, formulation of fuels, food industry, etc., and, furthermore, applications within clinical testing, dissolution and digestion of samples with acid etc. where a liquid reactant is added to a liquid or solid. The invention is in particular aimed at applications where open vessels cannot be used, and more specifically for applications where it is required to operate at temperatures which will cause elevated pressures in the liquid part of the mixture.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Further advantages and characteristic features of the present invention are illustrated in the following description by referring to the drawings which, as mere examples without limitations, show some designs related to this invention, where Figure 1 present a side-view of the multiautoclave with the single components disassembled, and Figure 2 shows a top-view of the multiautoclave, while Figure 3 shows an alternative design of the multiautoclave (side-view). Figure 4 shows a section of one of the chambers of the multiautoclave (side view) equipped with a Teflon liner and disc-shaped lids. Figure 5a shows a section of the multiautoclave in "exploded" view, and in Figure 5b in closed mode.

Figure 6 presents an example of different chemical compositions covered in one single experiment using the multiautoclave.

More specifically, the invention comprises a unit containing a multitude of pressure vessels, also referred to as a multiautoclave. This multiautoclave has typically from 10 to 10.000 or more small, separate chambers (1), each typically with a volume of 0.001 - 10 ml. The multiautoclave is composed of a set of plates (2 and 7) and optionally thin laminae (3) which are stacked so that they form a matrix of small chambers (1), as shown

in Figures 1 - 5. The thickness of the different plates and laminae may vary, always keeping in mind that a maximum number of small chambers with optimal size is desired, and that the chambers must be leak tight and dimensioned such that no excessive degree of deformation will take place under the operational conditions which the equipment is designed for. The central block consisting in a perforated plate (2), with a multitude of perforations, serve - when sandwiched between the plates (7a and 7b) and closed - as the frame of the pressure chambers, and may for use at higher temperatures (150 - 250°C) be made from stainless steel, aluminium, titanium or other rigid material s.a. PEEK or the like, with perforations of e.g. 10 mm diameters, where each perforation is lined with a segment of Teflon tubing or tubing made from another suitable polymer material, and where the walls of the linings e.g. can have a thickness of 1-3 mm. For use at temperatures below 150°C, the central block can be made entirely of Teflon, and for use below 130°C it can be made of polypropylene, and for use below 105°C it can be made of polyethylene. In the separate pressure chambers, balls (4) made from Teflon or other suitable material s.a. steel, PEEK, Nylon or glass may be used as a bottom- and toplid, also referred to as sealing means or septa (5) made from an elastomer or from another appropriate material s.a. Teflon in the shape of circular disks which will give the advantage in the form of reduced weight and volume. Septa should be made from an elastomer, preferably Viton, or other suitable material that can withstand temperatures of at least 200°C, and they may be equipped with Teflon lining (13) on the side facing the chamber as shown in Figures 4 and 5. Furthermore, said septa (5) should have a thickness considerably larger than the depth of immersion, as shown on Figure 3, in order to ensure a tight fit when assembling the different elements. As an alternative, septa or balls may be fastened on the bottom and top plates or on separate polymer films or a thin metal plate in such a way that they may be put in place and removed in a simple manner. The bottom and top plates (7) thus hold balls, septa, stoppers or other types of suitable cover means in place as the central block (2) is squeezed between the bottom and top plates. In order to avoid the use of balls, septa, stoppers or loose parts, the bottom and top plates can also be designed with a structure that has conical or hemispheric protrusions that fit into the perforations. Another design comprises polymer films moulded or otherwise shaped to cover all the perforations. In yet another design, the central block has been machined so that sharp edges (14) protrude around each perforation or well, as shown in Figure 5. The advantage of this design is that one smooth polymer sheet can be used as a lid or sealing device for all the chambers because the sharp protrusions cut into this polymer sheet so that leakage between adjacent chambers does not occur when the reaction vessel is closed with its locking mechanism. Said sharp protrusions (14) could alternatively consist of rings or e.g. a rectangular grid that are either welded onto the central block (2) or fastened by any other suitable method. These said protrusions may optionally be part of the insides

of the top (7b)- and bottom plates (7a) or the central block (2). The important point here is that the load used when assembling the different elements is concentrated just at the edges of the perforations and lids, so that liquid or vapour cannot leak out during heating.

5 In one embodiment, all plates and laminae have a series of holes drilled through (6) for locking means, which can be bolts which are used to assemble the multiautoclave and ensure a sufficient counter-pressure to prevent leakage when the liquid in the chambers is heated to high temperatures, and the bolts are placed in such a manner and their number is adjusted so that a sufficiently distributed even load is obtained in order to ensure that all
10 the chambers are tight when in use. The multiautoclave may alternatively be closed by pressing the plates against each other employing a clamping or squeezing mechanism that makes through-going bolts unnecessary. The squeezing mechanism may include springs or the like, which ensure the maintenance of a suitable pressure. A frame made of a rigid material that ensures good tightness in the outer chambers may enclose the entire
15 multiautoclave, also counteracting deformation of plates made of pure Teflon or another ductile material. Bolts and frames or whatever other locking mechanisms used are tightened with a torque wrench in order to ensure correct load throughout. A possible feature of the design is that a large number of plates may be placed on top of each other forming layers of reaction chambers according to the desired capacity. As an example, 10
20 plates with pressure chambers can be placed on top of each other without requiring a total multiautoclave thickness of more than typically 25 - 40 cm. Another important feature of this invention is that the large number of chambers which are created by the described assembly of the various described parts subsequent to performing e. g. a number of
25 syntheses can be opened in both ends. This makes simple and efficient recovery and washing of the synthesis products possible, and as an example on how this can be performed, the top plate with associated lid (e.g. septum) is removed first, and a filter paper placed over it and pressed against the plate with a sponge or another suitable absorbent or a filter supported by a rigid grid connected to a pump. The multiautoclave is then turned upside-down, and the bottom plate with associated lid is removed. The liquid
30 in the reaction chambers can then drain through the filter, and the synthesis product can be washed by flushing down through the perforations. As a result, the final, washed synthesis products are each in its own position on the filter paper, and these positions correspond to the positions of the perforations of the mainblock in the multiautoclave, so that identification of the synthesis products can be achieved. The samples are placed in a well-
35 defined matrix that, in principle, in a simple manner can be transferred to an automatic sample-switching unit for analysis, e.g. by X-ray diffraction. It is often desirable to calcine inorganic samples after synthesis, and for this purpose the samples can be washed

from the multiautoclave and into the perforations of another block which is made of a material suitable for performing calcination s.a. stainless steel or quartz.

Whenever the perforations, which on closing form the pressure chambers are going through the central block, the bottom has to be closed before charging with liquid or other reactants. This can be achieved in a simple manner by placing the perforated plate (2) on top of a plate (7a) with balls, septa or other sealing devices between them. The two plates (2 and 7a) are then bolted together with a set of bolts (9) with lengths somewhat less than the combined thickness of the two plates, so that no part of the bolts is protruding from the plate assembly. In the example shown in Figure 2, six bolts placed as illustrated have been found to be sufficient to hold the bottom plate sufficiently tight to the central block. After the chambers have been charged, the top plate (7b) with its sealing devices is put in place, and another set of bolts (11), which are considerably longer than the thickness of the entire multiautoclave, is put through a separate set of through-going holes (6) and tightened with nuts (12) at the bottom side with a torque wrench and with a load sufficient to keep the multiautoclave tight under the prevailing synthesis conditions it is going to be exposed to. Springs adjusted to a suitable pressure can, for instance, be put on the bolts before placing the nuts on them.

The advantages of the present invention are primarily related to the large rationalization gain that gives a correspondingly large economic saving. The saving is estimated to be from 90 to 99%. In other words, either the cost related to a given synthesis program is reduced by 90 - 99%, or it is possible for a given amount of money to perform 10 - 100 times as many syntheses. Such an automated layout will make it possible to perform e.g. 1000 syntheses/formulations simultaneously, and it will thus be very useful for all research laboratories, in industry as well as in research institutions/ universities.

Multiautoclaves suited for the purposes mentioned above might be designed as described in the following examples, but the descriptions are to be considered merely as examples of possible designs and the given measurements and other details shall not be considered to be limitations to the invention.

Example 1

A multiautoclave is built from 5 layers as shown in Figure 1. The different layers are placed on top of each other and bolted together so that 100 hermetically sealed chambers (1) are formed. By stacking several layers in a suitable way, it is possible to make a multiautoclave with, e.g. 1000 chambers or more. A decisive element in the invention described here is the combination of steel balls (4) and a thin polymer film (3) for the

closing of the small chambers in the multiautoclave. In as much as the contact between the edge of the perforation and the steel ball is exposed to the total pressure developed by tightening the bolts, the multiautoclave will be tight aided by slight deformation of the ductile parts.

The multiautoclave is from bottom to top built up from the following elements as shown in Figure 1. Bottom plate (7a) made from aluminium or steel, with 100 symmetrically positioned cavities (8), each with a diameter of 13 mm. Each cavity has a depth of 8 mm, and stainless steel balls (4) with diameters of 13 mm are placed in each cavity. In addition, the plate has 9 smaller, through-going holes (6) for bolts that are used to keep all the plates bolted together. Furthermore, a thin polymer film (3a) made of Teflon, and the purpose of this film is to tighten against the perforations in the perforated plate (2) and to avoid direct contact between the steel balls (4) and the synthesis mixtures. The polymer film has 9 smaller holes (6) through it for bolts used to keep all the plates together. Further, a 2 cm thick Teflon plate (2) with 100 symmetrically positioned perforations with diameter 8 mm. In addition, the plate has 9 smaller holes (6) going through it for bolts used to keep all the plates together. There is also another set of holes (10) through the bottom plate (7a) and the perforated plate (2) that is used to keep these two plates with the corresponding balls tightly together while adding liquid. Furthermore, another thin polymer film (3b) made from 0.5 mm Teflon, and the purpose and design of this film is the same as for (3a). A top plate (7b) is placed above this, identical to the bottom plate (7a), but inverted in relation to it.

A frame ensuring good tightening of the outer chambers by preventing lateral deformation of the Teflon block (2) is fastened around the multiautoclave (not shown).

Example 2

In another embodiment, a multiautoclave was designed and built as shown in Figure 3. In this case, Teflon-lined septa (5) type "MICROSEP F138" from Alltech which are stable up to 250°C were used as bottom- and top-lids for each of the small chambers.

The multiautoclave was constructed from the following elements according to Figure 3. A bottom aluminium plate (7a), 2 cm thick with 9 smaller, through-going holes for bolts (11) used for holding all the plates bolted together. Above this plate a 2 cm thick Teflon plate with 100 symmetrically positioned perforations with diameters 8 mm is mounted. Further, above and below each perforation there is a 1 mm deep recess with diameter 13 mm where Teflon-lined septa (5) with thickness of 2 mm are placed. This plate also has 9 smaller, through-going holes for bolts used to keep all the plates bolted together. There is

also a set of 6 holes (10) with associated bolts (9) used to hold the bottom plate (7a) and the central block (2) together.

An upper aluminium plate (7b), 2 cm thick, is placed on top. This plate also has 9 smaller, through-going holes for bolts (11) used to keep all the plates bolted together.

In order to test the designed multiautoclave, the bottom plate (7a) and the central block (2) (Figure 3) were bolted together so that a plate with 100 wells and solid bottom embedding the septa (5) was formed. The resulting were each filled with 0.5 ml water, and a top plate with the associated septa was fastened to it by bolts. The multiautoclave was then placed in a heating cabinet at 150°C for three days. When the multiautoclave was opened after three days, the liquid levels in the 100 chambers were unchanged.

Example 3

In yet another embodiment, a heavy duty multiautoclave was designed and built essentially as shown in Figure 3, but in this case the 20 mm thick central block (2) was made of 316-stainless steel with 13.75 mm wells which were 19 mm deep. The remaining 1 mm of the plate was drilled through with a diameter of 12.45 mm resulting in a design, essentially, as displayed in Figure 4. The 13.75 mm perforations were lined with Teflon cylinders (13) with 2.75 mm wall thickness and 18 mm length so that above and below each cylinder there is a 1 mm deep recess with diameter 13.75 in one end and 12.45 in the other end. 3 mm thick Teflon disks with 13.75 mm and 12.45 mm diameters, respectively, (5) were used as bottom- and top lids for each of the small chambers.

Example 4

The bottom plate (7a) and the central block (2) of the multiautoclave described in Example 2 with septa (5) embedded were bolted together so that a plate with 100 wells with solid bottom was formed. This plate was then connected to an automatic pipetting machine of the "Tecan miniprepTM" type which was programmed to dispense the desired amounts from 4 different solutions to each of the 100 wells, so that a total of 100 reaction mixtures with different compositions was prepared in about 30 min.

Example 5

A multiautoclave as described in Example 1 was used for 64 zeolite syntheses based on 56 different gel compositions derived from 4 different solutions, including water, so that it covered the composition range for the Na - Si - Al system shown in Figure 6. The matrix had 64 points, but 8 of these were excluded because they appeared outside the desired range. The 8 spare chambers were instead used for reproductions, so that the total

number of different compositions were 56, and these 56 compositions are given as molecular ratios in Table 1 and as volume units in Table 2, and the last 5 columns in Table 2 are volume units adjusted so that each small synthesis chamber will contain an exact volume of 0.5 ml synthesis mixture.

The four solutions were prepared so that all Si is dissolved in solution no. 4 and all Al is dissolved in solution no. 1. Solution no. 1 also contains an amount of NaOH sufficient to keep Al dissolved as well as water as solvent. Solution no. 3 was used to make-up the NaOH concentration (corrected for Na content in solutions no. 1 and no. 4), and finally, water was used to make-up the amount of water required for the recipe. All solutions were normalized to 500 μ l. The compositions of the four solutions were:

1. 100 g NaAlO_2 + 8.5 g NaOH + 391.5 g water
2. 21.8 g NaOH + 100 g water
3. Water
4. Ludox LS-30 which is 30% silica sol in water

The solutions were prepared in the order and amounts given in Table 1, and automatic pipettes were used for charging the multiautoclave chambers with the solutions. Four gel compositions were chosen as reproductions, and three parallels of these were made in the multiautoclave and, in addition, a larger scale (approx. 40 g gel) synthesis was performed in a separate plastic flask as a control of the possible effects of down- or up scaling. The four reproductions were chosen so that they represented points in the range of the four zeolitic phases FAU, CHA, GML and LTA given in Figure 4.5.c on page 70 in "Zeolite Molecular Sieves, Structure Chemistry and Use" by D. W. Breck, 1974, Wiley and Sons, New York.

The multiautoclave was placed in a heating cabinet after being kept over-night at room temperature. It was opened after 93 hours of crystallization at 100°C, and it was established that all 64 chambers had stayed tight without leakage, and a large filter paper was placed so that it covered the 64 perforations and a moisture absorbing material was pressed against the outside of the filter paper so that remaining moisture was separated from the crystalline products. The products were washed by adding a small aliquot of water (ca. 0.5 ml) to each perforation for washing. Thereafter, when the solid material was transferred to the filter paper, the perforated Teflon plate was removed and the 64 filter "cakes" were transferred to 64 separate glass sample vials. The samples were then dried at 100°C in a drying cabinet.

TABLE 1

| SiO2/Al2O3 | Na2O/Al2O3 | SiO2/Na2O | sum | SiO2 | Na2O | Al2O3 | H2O |
|------------|------------|-----------|-------|-------|-------|-------|------|
| 1.0 | 1.5 | 0.654 | 3.53 | 0.283 | 0.433 | 0.283 | 19.0 |
| 1.0 | 1.9 | 0.526 | 3.90 | 0.256 | 0.487 | 0.266 | 19.0 |
| 1.0 | 2.4 | 0.417 | 4.40 | 0.227 | 0.545 | 0.227 | 19.0 |
| 1.0 | 3.0 | 0.333 | 5.00 | 0.200 | 0.600 | 0.200 | 19.0 |
| 1.0 | 4.0 | 0.250 | 6.00 | 0.167 | 0.667 | 0.167 | 19.0 |
| 1.5 | 1.5 | 0.980 | 4.03 | 0.372 | 0.380 | 0.248 | 19.0 |
| 1.5 | 1.9 | 0.789 | 4.40 | 0.341 | 0.432 | 0.227 | 19.0 |
| 1.5 | 2.4 | 0.625 | 4.90 | 0.306 | 0.490 | 0.204 | 19.0 |
| 1.5 | 3.0 | 0.500 | 5.50 | 0.273 | 0.545 | 0.182 | 19.0 |
| 1.5 | 4.0 | 0.375 | 6.50 | 0.231 | 0.615 | 0.154 | 19.0 |
| 1.5 | 5.3 | 0.283 | 7.80 | 0.192 | 0.679 | 0.128 | 19.0 |
| 1.5 | 8.0 | 0.188 | 10.50 | 0.143 | 0.762 | 0.095 | 19.0 |
| 2.3 | 1.5 | 1.503 | 4.83 | 0.476 | 0.317 | 0.207 | 19.0 |
| 2.3 | 1.9 | 1.211 | 5.20 | 0.442 | 0.365 | 0.192 | 19.0 |
| 2.3 | 2.4 | 0.958 | 5.70 | 0.404 | 0.421 | 0.175 | 19.0 |
| 2.3 | 3.0 | 0.767 | 6.30 | 0.385 | 0.476 | 0.159 | 19.0 |
| 2.3 | 4.0 | 0.575 | 7.30 | 0.315 | 0.548 | 0.137 | 19.0 |
| 2.3 | 5.3 | 0.434 | 8.60 | 0.267 | 0.616 | 0.116 | 19.0 |
| 2.3 | 8.0 | 0.288 | 11.30 | 0.204 | 0.708 | 0.088 | 19.0 |
| 2.8 | 1.5 | 1.830 | 5.33 | 0.525 | 0.287 | 0.188 | 19.0 |
| 2.8 | 1.9 | 1.474 | 5.70 | 0.491 | 0.333 | 0.175 | 19.0 |
| 2.8 | 2.4 | 1.167 | 6.20 | 0.452 | 0.387 | 0.161 | 19.0 |
| 2.8 | 3.0 | 0.933 | 6.80 | 0.412 | 0.441 | 0.147 | 19.0 |
| 2.8 | 4.0 | 0.700 | 7.80 | 0.359 | 0.513 | 0.128 | 19.0 |
| 2.8 | 5.3 | 0.528 | 9.10 | 0.308 | 0.582 | 0.110 | 19.0 |
| 2.8 | 8.0 | 0.350 | 11.80 | 0.237 | 0.678 | 0.085 | 19.0 |
| 4.0 | 1.5 | 2.614 | 6.53 | 0.613 | 0.234 | 0.153 | 19.0 |
| 4.0 | 1.9 | 2.105 | 6.90 | 0.580 | 0.275 | 0.145 | 19.0 |
| 4.0 | 2.4 | 1.667 | 7.40 | 0.541 | 0.324 | 0.135 | 19.0 |
| 4.0 | 3.0 | 1.333 | 8.00 | 0.500 | 0.375 | 0.125 | 19.0 |
| 4.0 | 4.0 | 1.000 | 9.00 | 0.444 | 0.444 | 0.111 | 19.0 |
| 4.0 | 5.3 | 0.755 | 10.30 | 0.388 | 0.515 | 0.097 | 19.0 |
| 4.0 | 8.0 | 0.500 | 13.00 | 0.308 | 0.615 | 0.077 | 19.0 |
| 4.0 | 12.0 | 0.333 | 17.00 | 0.235 | 0.706 | 0.059 | 19.0 |
| 6.0 | 1.5 | 3.922 | 8.53 | 0.703 | 0.179 | 0.117 | 19.0 |
| 6.0 | 1.9 | 3.158 | 8.90 | 0.674 | 0.213 | 0.112 | 19.0 |
| 6.0 | 2.4 | 2.500 | 9.40 | 0.638 | 0.255 | 0.106 | 19.0 |
| 6.0 | 3.0 | 2.000 | 10.00 | 0.600 | 0.300 | 0.100 | 19.0 |
| 6.0 | 4.0 | 1.500 | 11.00 | 0.545 | 0.364 | 0.091 | 19.0 |
| 6.0 | 5.3 | 1.132 | 12.30 | 0.488 | 0.431 | 0.081 | 19.0 |
| 6.0 | 8.0 | 0.750 | 15.00 | 0.400 | 0.533 | 0.067 | 19.0 |
| 6.0 | 12.0 | 0.500 | 19.00 | 0.316 | 0.632 | 0.053 | 19.0 |
| 10.0 | 1.5 | 6.536 | 12.53 | 0.798 | 0.122 | 0.080 | 19.0 |
| 10.0 | 1.9 | 5.263 | 12.90 | 0.775 | 0.147 | 0.078 | 19.0 |
| 10.0 | 2.4 | 4.167 | 13.40 | 0.746 | 0.179 | 0.075 | 19.0 |
| 10.0 | 3.0 | 3.333 | 14.00 | 0.714 | 0.214 | 0.071 | 19.0 |
| 10.0 | 4.0 | 2.500 | 15.00 | 0.667 | 0.267 | 0.067 | 19.0 |
| 10.0 | 5.3 | 1.887 | 16.30 | 0.613 | 0.325 | 0.061 | 19.0 |
| 10.0 | 8.0 | 1.250 | 19.00 | 0.526 | 0.421 | 0.053 | 19.0 |
| 10.0 | 12.0 | 0.833 | 23.00 | 0.435 | 0.522 | 0.043 | 19.0 |
| 20.0 | 1.5 | 13.072 | 22.53 | 0.888 | 0.068 | 0.044 | 19.0 |
| 20.0 | 2.4 | 8.333 | 23.40 | 0.855 | 0.103 | 0.043 | 19.0 |
| 20.0 | 4.0 | 5.000 | 25.00 | 0.800 | 0.160 | 0.040 | 19.0 |
| 20.0 | 5.3 | 3.774 | 26.30 | 0.760 | 0.202 | 0.038 | 19.0 |
| 20.0 | 8.0 | 2.500 | 29.00 | 0.690 | 0.276 | 0.034 | 19.0 |
| 20.0 | 12.0 | 1.667 | 33.00 | 0.606 | 0.384 | 0.030 | 19.0 |

TABLE 2

volume units of solution

microliter solution

| ludox LS-30 | soln 1 | soln 2 | vann | sum | factor | ludox LS-30 | soln 1 | soln 2 | vann | sum |
|-------------|--------|--------|-------|--------|--------|-------------|---------|--------|---------|-----|
| 46.82415 | 221.8 | 8.8032 | 80.2 | 357.68 | 1.398 | 65.46673 | 310.122 | 12.306 | 112.117 | 500 |
| 42.38186 | 200.8 | 44.782 | 67.85 | 355.81 | 1.405 | 59.65614 | 282.17 | 62.928 | 95.3453 | 500 |
| 37.56674 | 178 | 83.788 | 54.46 | 353.79 | 1.413 | 63.08987 | 261.634 | 118.41 | 76.963 | 500 |
| 33.05785 | 156.6 | 120.3 | 41.92 | 351.9 | 1.421 | 46.97017 | 222.539 | 170.92 | 59.566 | 500 |
| 27.54821 | 130.5 | 164.92 | 26.6 | 349.59 | 1.43 | 39.40061 | 186.676 | 235.88 | 38.0473 | 500 |
| 61.52206 | 194.3 | 7.5557 | 95.47 | 358.87 | 1.393 | 85.71586 | 270.741 | 10.527 | 133.018 | 500 |
| 56.34861 | 178 | 39.551 | 83.24 | 357.12 | 1.4 | 78.89315 | 249.191 | 65.374 | 116.541 | 500 |
| 50.59875 | 169.8 | 75.11 | 69.64 | 355.17 | 1.408 | 71.23129 | 224.99 | 105.74 | 98.0404 | 500 |
| 45.07889 | 142.4 | 109.25 | 56.59 | 353.3 | 1.415 | 63.79643 | 201.507 | 154.61 | 80.0876 | 500 |
| 38.14367 | 120.5 | 162.14 | 40.19 | 350.95 | 1.425 | 54.34291 | 171.647 | 216.75 | 57.2803 | 500 |
| 31.7864 | 100.4 | 191.45 | 25.16 | 348.8 | 1.433 | 45.58532 | 143.922 | 274.45 | 36.0653 | 500 |
| 23.81276 | 74.58 | 242 | 5.832 | 346.03 | 1.445 | 34.11934 | 107.769 | 349.68 | 8.42692 | 500 |
| 78.70917 | 162.1 | 6.0969 | 113.3 | 360.27 | 1.388 | 109.2369 | 225.022 | 8.4618 | 157.279 | 500 |
| 73.10871 | 150.6 | 33.273 | 101.7 | 358.69 | 1.394 | 101.9118 | 209.933 | 46.382 | 141.773 | 500 |
| 66.89566 | 137.4 | 64.393 | 88.4 | 355.87 | 1.401 | 93.4441 | 192.49 | 90.218 | 123.848 | 500 |
| 60.3437 | 124.3 | 95.216 | 75.22 | 355.08 | 1.408 | 84.9719 | 175.038 | 134.08 | 105.913 | 500 |
| 52.07744 | 107.3 | 136.33 | 58.06 | 352.75 | 1.417 | 73.81736 | 162.06 | 191.82 | 82.3009 | 500 |
| 44.20527 | 91.06 | 173.53 | 41.73 | 350.52 | 1.426 | 63.05645 | 129.893 | 247.53 | 59.5216 | 500 |
| 33.64295 | 69.3 | 224.78 | 19.81 | 347.54 | 1.439 | 48.40187 | 99.7054 | 323.39 | 28.4998 | 500 |
| 85.83113 | 145.9 | 5.4076 | 121.8 | 360.93 | 1.386 | 120.2887 | 203.541 | 7.4911 | 188.68 | 500 |
| 81.19472 | 137.4 | 30.245 | 110.6 | 359.44 | 1.391 | 112.9455 | 191.115 | 42.072 | 153.867 | 500 |
| 74.64676 | 126.3 | 59.099 | 97.66 | 367.72 | 1.398 | 104.3381 | 176.551 | 82.606 | 138.505 | 500 |
| 68.06028 | 115.2 | 88.123 | 84.63 | 355.98 | 1.405 | 95.59593 | 161.758 | 123.78 | 118.871 | 500 |
| 59.3346 | 100.4 | 126.57 | 67.37 | 353.69 | 1.414 | 83.88217 | 141.937 | 178.94 | 95.2423 | 500 |
| 50.85823 | 86.06 | 163.93 | 50.6 | 351.44 | 1.423 | 72.35622 | 122.434 | 233.22 | 71.9928 | 500 |
| 39.22718 | 66.37 | 215.2 | 27.58 | 348.38 | 1.436 | 56.29159 | 95.2511 | 308.87 | 39.5881 | 500 |
| 101.2482 | 119.9 | 4.1838 | 136.7 | 382.1 | 1.381 | 139.8085 | 165.599 | 5.7771 | 188.815 | 500 |
| 95.81986 | 113.6 | 24.767 | 126.7 | 360.81 | 1.386 | 132.7847 | 157.28 | 34.322 | 175.614 | 500 |
| 89.34554 | 105.6 | 49.312 | 114.8 | 359.27 | 1.392 | 124.3431 | 147.281 | 68.629 | 159.748 | 500 |
| 82.64463 | 97.89 | 74.717 | 102.4 | 357.68 | 1.398 | 115.5296 | 136.841 | 104.45 | 143.182 | 500 |
| 73.46189 | 87.01 | 109.53 | 85.49 | 355.49 | 1.406 | 103.3234 | 122.384 | 164.05 | 120.24 | 500 |
| 64.19 | 76.03 | 144.68 | 68.39 | 353.29 | 1.415 | 90.84579 | 107.604 | 204.76 | 96.788 | 500 |
| 50.85823 | 60.24 | 195.22 | 43.8 | 350.12 | 1.428 | 72.62926 | 86.0273 | 278.79 | 62.5493 | 500 |
| 38.89159 | 46.07 | 240.59 | 21.73 | 347.28 | 1.44 | 55.99491 | 66.3244 | 346.4 | 31.2843 | 500 |
| 116.2644 | 91.81 | 2.9093 | 162.3 | 363.32 | 1.378 | 160.0031 | 126.346 | 4.0038 | 209.647 | 500 |
| 111.431 | 87.99 | 18.92 | 143.9 | 362.27 | 1.38 | 153.7963 | 121.445 | 28.114 | 198.645 | 500 |
| 105.5038 | 83.31 | 38.554 | 133.6 | 360.98 | 1.385 | 146.1356 | 115.396 | 53.402 | 185.067 | 500 |
| 99.17355 | 78.31 | 59.523 | 122.6 | 359.6 | 1.39 | 137.8934 | 108.887 | 82.782 | 170.457 | 500 |
| 90.15778 | 71.19 | 89.388 | 106.9 | 357.64 | 1.398 | 126.0449 | 99.531 | 124.97 | 149.456 | 500 |
| 80.62891 | 63.67 | 120.95 | 90.32 | 355.57 | 1.406 | 113.38 | 89.5303 | 170.08 | 127.007 | 500 |
| 66.1157 | 52.21 | 169.03 | 65.06 | 352.41 | 1.419 | 93.80433 | 74.0723 | 239.81 | 92.309 | 500 |
| 52.19661 | 41.22 | 215.13 | 40.84 | 349.39 | 1.431 | 74.69769 | 58.9848 | 307.88 | 58.4422 | 500 |
| 131.9148 | 62.5 | 1.681 | 168.6 | 364.59 | 1.371 | 180.9081 | 85.7122 | 2.1682 | 231.212 | 500 |
| 128.1312 | 60.71 | 12.665 | 162.3 | 363.83 | 1.374 | 176.0871 | 83.428 | 17.408 | 223.079 | 500 |
| 123.3502 | 58.44 | 26.672 | 154.4 | 362.87 | 1.378 | 169.9663 | 80.5281 | 36.751 | 212.754 | 500 |
| 118.0838 | 55.94 | 42.159 | 145.6 | 361.8 | 1.382 | 163.1606 | 77.3038 | 58.262 | 201.274 | 500 |
| 110.1928 | 52.21 | 65.217 | 132.6 | 360.22 | 1.388 | 152.9531 | 72.4674 | 90.525 | 184.055 | 500 |
| 101.4045 | 48.04 | 90.964 | 118 | 359.45 | 1.395 | 141.4491 | 67.017 | 125.89 | 164.849 | 500 |
| 86.99435 | 41.22 | 133.18 | 94.16 | 355.55 | 1.406 | 122.3386 | 57.9628 | 187.29 | 132.411 | 500 |
| 71.88489 | 34.05 | 177.5 | 69.09 | 352.5 | 1.418 | 101.9356 | 48.2959 | 251.77 | 97.9937 | 500 |
| 148.7281 | 34.76 | 0.3237 | 184 | 365.79 | 1.367 | 200.5611 | 47.5118 | 0.4424 | 251.485 | 500 |
| 141.2729 | 33.47 | 14.739 | 175.3 | 364.76 | 1.371 | 193.6507 | 45.8747 | 20.203 | 240.271 | 500 |
| 132.2314 | 31.32 | 38.63 | 160.9 | 363.05 | 1.377 | 182.1111 | 43.1411 | 53.201 | 221.548 | 500 |
| 125.6953 | 29.78 | 55.901 | 150.4 | 361.81 | 1.382 | 173.7011 | 41.1488 | 77.25 | 207.9 | 500 |
| 113.9926 | 27 | 86.824 | 131.8 | 359.6 | 1.39 | 158.4988 | 37.6475 | 120.72 | 183.231 | 500 |
| 100.1753 | 23.73 | 123.33 | 109.7 | 356.99 | 1.401 | 140.3068 | 33.2379 | 172.74 | 153.712 | 500 |

R = point reproduced

Example 6

In another embodiment, pre-mixed gels of aluminumphosphate, silicoaluminumphosphate and cobaltaluminumphosphate were prepared and administered by means of the "Tecan MiniprepTM" to the 100 cavities of the multiautoclave of example 3. Thereafter 6 different organic compounds were added according to the molar ratios specified in Table 3. The multiautoclave was then closed and was heated for 48 h in an oven at 200°C. The solid synthesis products were recovered as described in example 5 and were dried overnight at ambient temperatures. The products were characterised by X-ray diffraction using a Siemens D-5000 diffractometer equipped with PSD detector and an automatic sample shifter. Several different crystalline phases were identified among the products including those of the structures AFI, ERI and CHA.

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TABLE 3

| Position | Mols AIPO gel | Mols SAPO gel | Mols CoAPO gel | R1 | Mols R1 | R2 | Mols R2 |
|----------|------------------|------------------|-------------------|-----------|---------|----|---------|
| 1 | 1 | 0 | 0 | CYCLOHEXY | 1 | - | 0 |
| 2 | 1 | 0 | 0 | MORPHOLIN | 1 | - | 0 |
| 3 | 1 | 0 | 0 | TRIPROPYL | 1 | - | 0 |
| 4 | 1 | 0 | 0 | DI-N-PROP | 1 | - | 0 |
| 5 | 1 | 0 | 0 | TEAOH | 1 | - | 0 |
| 6 | 1 | 0 | 0 | TRIETHYLA | 1 | - | 0 |
| 7 | 0 | 1 | 0 | CYCLOHEXY | 1 | - | 0 |
| 8 | 0.25 | 0.75 | 0 | CYCLOHEXY | 1 | - | 0 |
| 9 | 0.5 | 0.5 | 0 | CYCLOHEXY | 1 | - | 0 |
| 10 | 0 | 1 | 0 | MORPHOLIN | 1 | - | 0 |
| 11 | 0.25 | 0.75 | 0 | MORPHOLIN | 1 | - | 0 |
| 12 | 0.5 | 0.5 | 0 | MORPHOLIN | 1 | - | 0 |
| 13 | 0 | 1 | 0 | TRIPROPYL | 1 | - | 0 |
| 14 | 0.25 | 0.75 | 0 | TRIPROPYL | 1 | - | 0 |
| 15 | 0.5 | 0.5 | 0 | TRIPROPYL | 1 | - | 0 |
| 16 | 0 | 1 | 0 | DI-N-PROP | 1 | - | 0 |
| 17 | 0.25 | 0.75 | 0 | DI-N-PROP | 1 | - | 0 |
| 18 | 0.5 | 0.5 | 0 | DI-N-PROP | 1 | - | 0 |
| 19 | 0 | 1 | 0 | TEAOH | 1 | - | 0 |
| 20 | 0.25 | 0.75 | 0 | TEAOH | 1 | - | 0 |
| 21 | 0.5 | 0.5 | 0 | TEAOH | 1 | - | 0 |
| 22 | 0 | 1 | 0 | TRIETHYLA | 1 | - | 0 |
| 23 | 0.25 | 0.75 | 0 | TRIETHYLA | 1 | - | 0 |
| 24 | 0.5 | 0.5 | 0 | TRIETHYLA | 1 | - | 0 |
| 25 | 0 | 0 | 1 | CYCLOHEXY | 1 | - | 0 |
| 26 | 0.25 | 0 | 0.75 | CYCLOHEXY | 1 | - | 0 |
| 27 | 0.5 | 0 | 0.5 | CYCLOHEXY | 1 | - | 0 |
| 28 | 0 | 0 | 1 | MORPHOLIN | 1 | - | 0 |
| 29 | 0.25 | 0 | 0.75 | MORPHOLIN | 1 | - | 0 |
| 30 | 0.5 | 0 | 0.5 | MORPHOLIN | 1 | - | 0 |
| 31 | 0 | 0 | 1 | TRIPROPYL | 1 | - | 0 |
| 32 | 0.25 | 0 | 0.75 | TRIPROPYL | 1 | - | 0 |
| 33 | 0.5 | 0 | 0.5 | TRIPROPYL | 1 | - | 0 |
| 34 | 0 | 0 | 1 | DI-N-PROP | 1 | - | 0 |
| 35 | 0.25 | 0 | 0.75 | DI-N-PROP | 1 | - | 0 |
| 36 | 0.5 | 0 | 0.5 | DI-N-PROP | 1 | - | 0 |
| 37 | 0 | 0 | 1 | TEAOH | 1 | - | 0 |
| 38 | 0.25 | 0 | 0.75 | TEAOH | 1 | - | 0 |
| 39 | 0.5 | 0 | 0.5 | TEAOH | 1 | - | 0 |
| 40 | 0 | 0 | 1 | TRIETHYLA | 1 | - | 0 |
| 41 | 0.25 | 0 | 0.75 | TRIETHYLA | 1 | - | 0 |
| 42 | 0.5 | 0 | 0.5 | TRIETHYLA | 1 | - | 0 |
| 43 | 0 | 0.25 | 0.75 | CYCLOHEXY | 1 | - | 0 |
| 44 | 0 | 0.5 | 0.5 | CYCLOHEXY | 1 | - | 0 |
| 45 | 0 | 0.75 | 0.25 | CYCLOHEXY | 1 | - | 0 |
| 46 | 0 | 0.25 | 0.75 | MORPHOLIN | 1 | - | 0 |
| 47 | 0 | 0.5 | 0.5 | MORPHOLIN | 1 | - | 0 |
| 48 | 0 | 0.75 | 0.25 | MORPHOLIN | 1 | - | 0 |
| 49 | 0 | 0.25 | 0.75 | TRIPROPYL | 1 | - | 0 |

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Table 3, gel compositions for MeAPO syntheses, continued.

| Position | Mols AIPO gel | Mols SAPO gel | Mols CoAPO gel | R1 | Mols R1 | R2 | Mols R2 |
|--|------------------|------------------|-------------------|-----------|---------|-----------|---------|
| 50 | 0 | 0.5 | 0.5 | TRIPROPYL | 1 | - | 0 |
| 51 | 0 | 0.75 | 0.25 | TRIPROPYL | 1 | - | 0 |
| 52 | 0 | 0.25 | 0.75 | DI-N-PROP | 1 | - | 0 |
| 53 | 0 | 0.5 | 0.5 | DI-N-PROP | 1 | - | 0 |
| 54 | 0 | 0.75 | 0.25 | DI-N-PROP | 1 | - | 0 |
| 55 | 0 | 0.25 | 0.75 | TEAOH | 1 | - | 0 |
| 56 | 0 | 0.5 | 0.5 | TEAOH | 1 | - | 0 |
| 57 | 0 | 0.75 | 0.25 | TEAOH | 1 | - | 0 |
| 58 | 0 | 0.25 | 0.75 | TRIETHYLA | 1 | - | 0 |
| 59 | 0 | 0.5 | 0.5 | TRIETHYLA | 1 | - | 0 |
| 60 | 0 | 0.75 | 0.25 | TRIETHYLA | 1 | - | 0 |
| 61 | 0 | 0 | 1 | CYCLOHEXY | 0.25 | MORPHOLIN | 0.75 |
| 62 | 0 | 0 | 1 | CYCLOHEXY | 0.25 | TRIPROPYL | 0.75 |
| 63 | 0 | 0 | 1 | CYCLOHEXY | 0.25 | DI-N-PROP | 0.75 |
| 64 | 0 | 0 | 1 | CYCLOHEXY | 0.25 | TEAOH | 0.75 |
| 65 | 0 | 0 | 1 | CYCLOHEXY | 0.25 | TRIETHYLA | 0.75 |
| 66 | 0 | 0 | 1 | MORPHOLIN | 0.25 | TRIPROPYL | 0.75 |
| 67 | 0 | 0 | 1 | MORPHOLIN | 0.25 | DI-N-PROP | 0.75 |
| 68 | 0 | 0 | 1 | MORPHOLIN | 0.25 | TEAOH | 0.75 |
| 69 | 0 | 0 | 1 | MORPHOLIN | 0.25 | TRIETHYLA | 0.75 |
| 70 | 0 | 0 | 1 | TRIPROPYL | 0.25 | DI-N-PROP | 0.75 |
| 71 | 0 | 0 | 1 | TRIPROPYL | 0.25 | TEAOH | 0.75 |
| 72 | 0 | 0 | 1 | TRIPROPYL | 0.25 | TRIETHYLA | 0.75 |
| 73 | 0 | 0 | 1 | DI-N-PROP | 0.25 | TEAOH | 0.75 |
| 74 | 0 | 0 | 1 | DI-N-PROP | 0.25 | TRIETHYLA | 0.75 |
| 75 | 0 | 0 | 1 | TEAOH | 0.25 | TRIETHYLA | 0.75 |
| 76 | 0 | 0 | 1 | CYCLOHEXY | 0.75 | MORPHOLIN | 0.25 |
| 77 | 0 | 0 | 1 | CYCLOHEXY | 0.75 | TRIPROPYL | 0.25 |
| 78 | 0 | 0 | 1 | CYCLOHEXY | 0.75 | DI-N-PROP | 0.25 |
| 79 | 0 | 0 | 1 | CYCLOHEXY | 0.75 | TEAOH | 0.25 |
| 80 | 0 | 0 | 1 | CYCLOHEXY | 0.75 | TRIETHYLA | 0.25 |
| 81 | 0 | 0 | 1 | MORPHOLIN | 0.75 | TRIPROPYL | 0.25 |
| 82 | 0 | 0 | 1 | MORPHOLIN | 0.75 | DI-N-PROP | 0.25 |
| 83 | 0 | 0 | 1 | MORPHOLIN | 0.75 | TEAOH | 0.25 |
| 84 | 0 | 0 | 1 | MORPHOLIN | 0.75 | TRIETHYLA | 0.25 |
| 85 | 0 | 0 | 1 | TRIPROPYL | 0.75 | DI-N-PROP | 0.25 |
| 86 | 0 | 0 | 1 | TRIPROPYL | 0.75 | TEAOH | 0.25 |
| 87 | 0 | 0 | 1 | TRIPROPYL | 0.75 | TRIETHYLA | 0.25 |
| 88 | 0 | 0 | 1 | DI-N-PROP | 0.75 | TEAOH | 0.25 |
| 89 | 0 | 0 | 1 | DI-N-PROP | 0.75 | TRIETHYLA | 0.25 |
| 90 | 0 | 0 | 1 | TEAOH | 0.75 | TRIETHYLA | 0.25 |
| 91-100 Reproductions chosen at random from compositions 1 - 90 | | | | | | | |

CYCLOHEX = Cyclohexylamine

MORPHOLI = morpholine

TRIPROPYL = tripropylamine

DI-N-PROP = dipropylamine

TEAOH = tetraethylammonium hydroxide

TRIETHYLA = triethylamine

Art. 34

PATENT CLAIMS

1. A multiautoclave reactor vessel for use at elevated pressures characterised by
- 5 a) a central block having a multitude of perforations, wherein said perforations are through-going perforations,
- b) cover means, operatively associated with a sealing means, for engagement with said central block to seal the open ends of said perforations forming a multitude of chambers,
- 10 c) a sealing means, operatively associated with the covers means, to form a pressure tight seal when said cover means is brought into position by a locking means,
- d) a locking means acting in concert with the cover means to engage the sealing means so as to define a multitude of reaction chambers.
2. A multiautoclave reactor vessel as claimed in claim 1, wherein said perforations are
- 15 cavities or other form of holes permanently closed at one end.
3. A multiautoclave reactor vessel as claimed in claim 1, wherein said sealing means is wholly or partly constructed of a compressible or deformable material.
- 20 4. A multiautoclave reactor vessel as claimed in claim 1, wherein said central block is wholly or partly constructed of a compressible or deformable material.
5. A multiautoclave reactor vessel as claimed in claim 1, wherein said sealing means is permanently fixed to the cover means.
- 25 6. A multiautoclave reactor vessel as claimed in claim 1, wherein said cover means, acting in concert with the sealing means, has a multitude of protrusions of spherical shape, form or profile, either in part or wholly, presenting a curved surface towards the openings of the multitude of perforations in the central block.
- 30 7. A multiautoclave reactor vessel as claimed in claim 1, wherein the sealing means consists of spherical shaped bodies or similar shaped components, permanently fixed to the cover means, such that they present a curved surface towards the opening of the multitude of perforations in the central block.
- 35

AMENDED SHEET

Act. 34

8. A multiautoclave reactor vessel as claimed in claim 1, wherein the sealing means consists of spherical shaped bodies or similar shaped components, loosely fixed to the cover means, such that they present a curved surface towards the opening of the multitude of perforations in the central block.

5

9. A multiautoclave reactor vessel as claimed in claim 1, wherein the sealing means consists of circular disks or other similar circular-shaped components that may be permanently fastened to the cover means.

10. A multiautoclave reactor vessel as claimed in claim 1, wherein the sealing means consists of circular disks or other similar circular-shaped components that may be loosely fastened to the cover means.

11. A multiautoclave reactor vessel as claimed in claim 1, wherein the sealing means consists of a flat plate or membrane, covering all the chambers, that may be permanently fastened to the cover means.

12. A multiautoclave reactor vessel as claimed in claim 1, wherein the sealing means consists of a flat plate or membrane, covering all the chambers, that may be loosely fastened to the cover means.

13. A multiautoclave reactor vessel as claimed in claim 1, wherein said locking means acts in concert with a single cover means on one surface of the central block to define a multitude of cavities.

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14. A multiautoclave reactor vessel as claimed in claim 1, wherein said locking means consists of a plurality of fasteners passing by means of appropriate holes from the upper surface of the upper cover means through the central block through to the lower surface of the lower cover means.

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15. A multiautoclave reactor vessel as claimed in claim 1, wherein said cover means is a rigid flat plate.

35

16. A multiautoclave reactor vessel as claimed in claim 1, wherein said cover means, acting in concert with the sealing means, has a multitude of protruding profiles of dimensions sufficiently larger than the dimensions of the perforations in the central block and of cross sectional shape such that in concert with the sealing means through the action

DEFENDED SHEET

APD 34

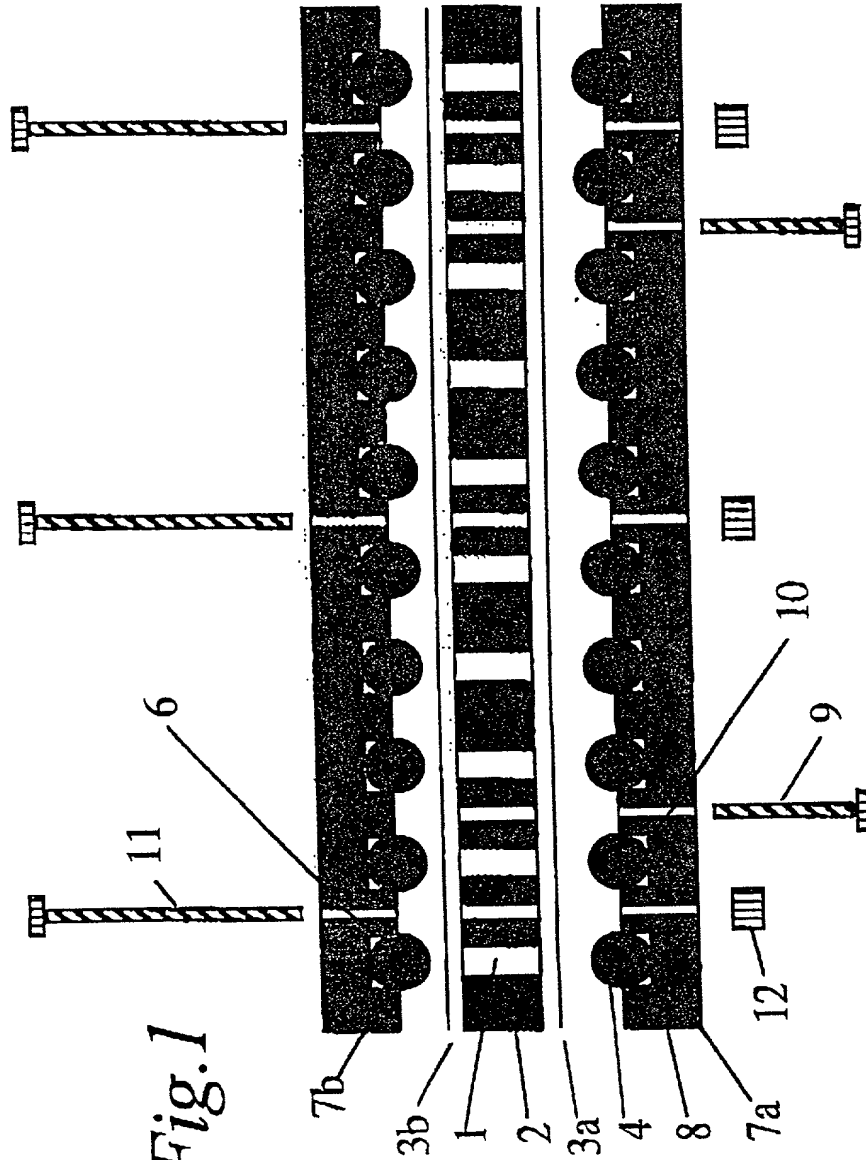
of the locking means, a pressure tight seal is formed over and around each of the multitude of perforations in the central block.

17. A multiautoclave reactor vessel as claimed in claim 1, wherein said central block,
5 acting in concert with the sealing means, has a multitude of protruding profiles of dimensions sufficiently larger than the dimensions of the perforations and of cross sectional shape such that in concert with the sealing means and through the action of the locking means on the cover means, a pressure tight seal is formed over and around each of the multitude of perforations in the central block.

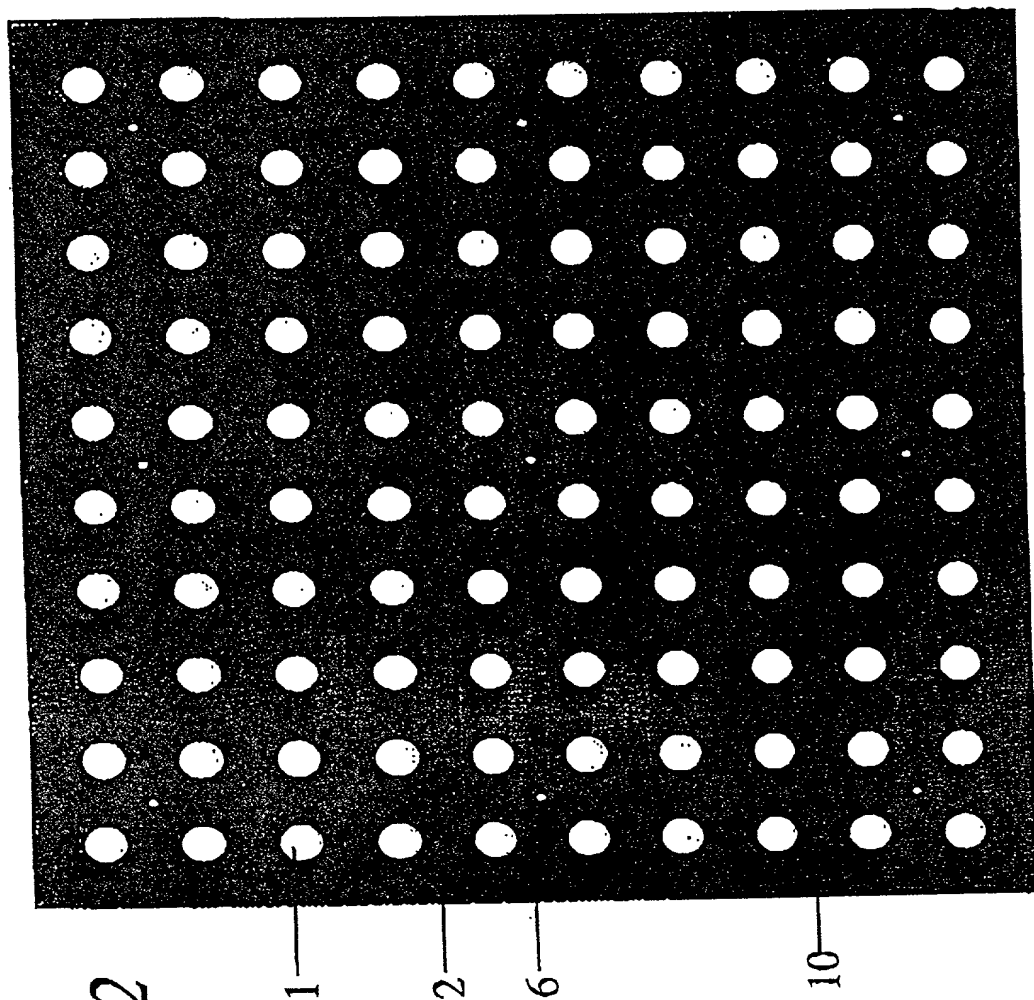
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• Fig. 1



• Fig. 2



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• Fig. 3

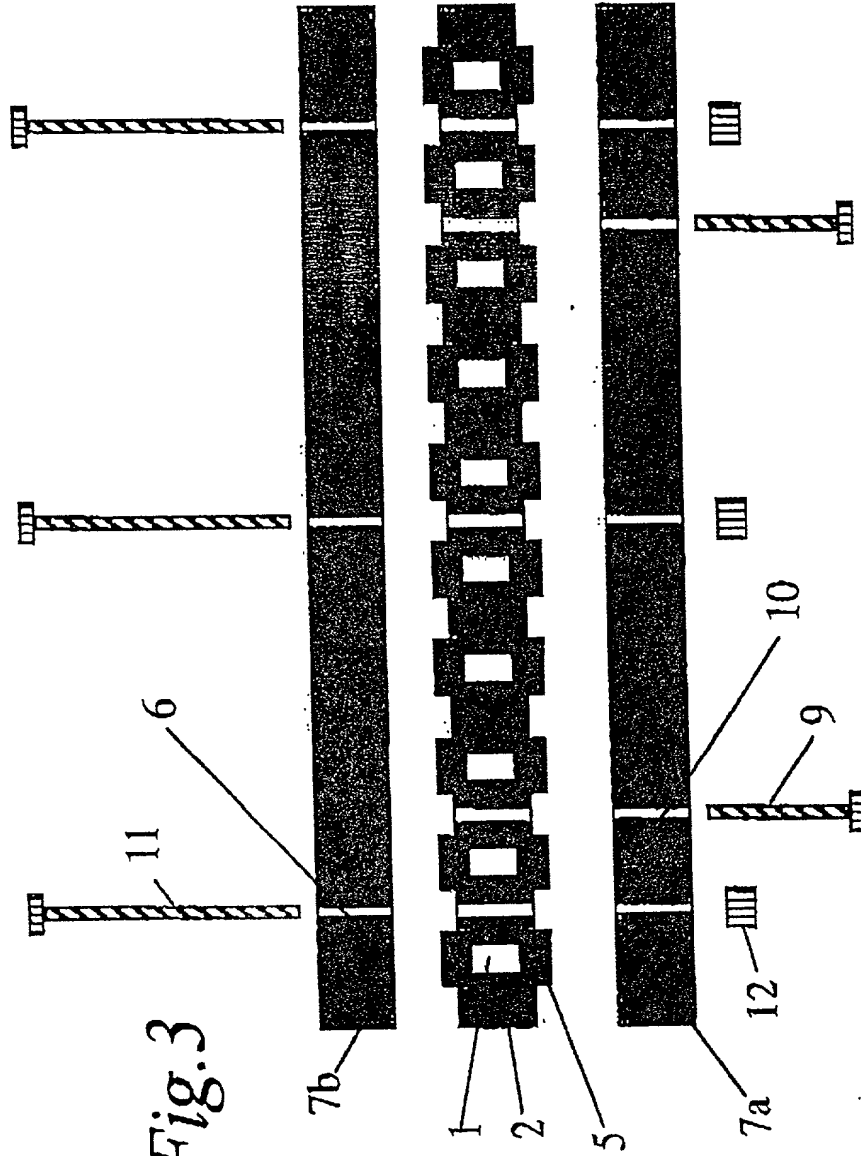
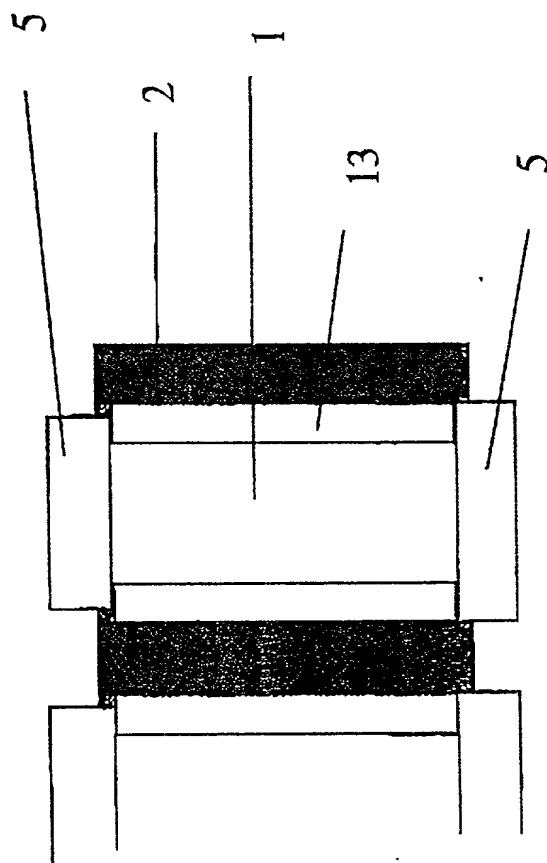
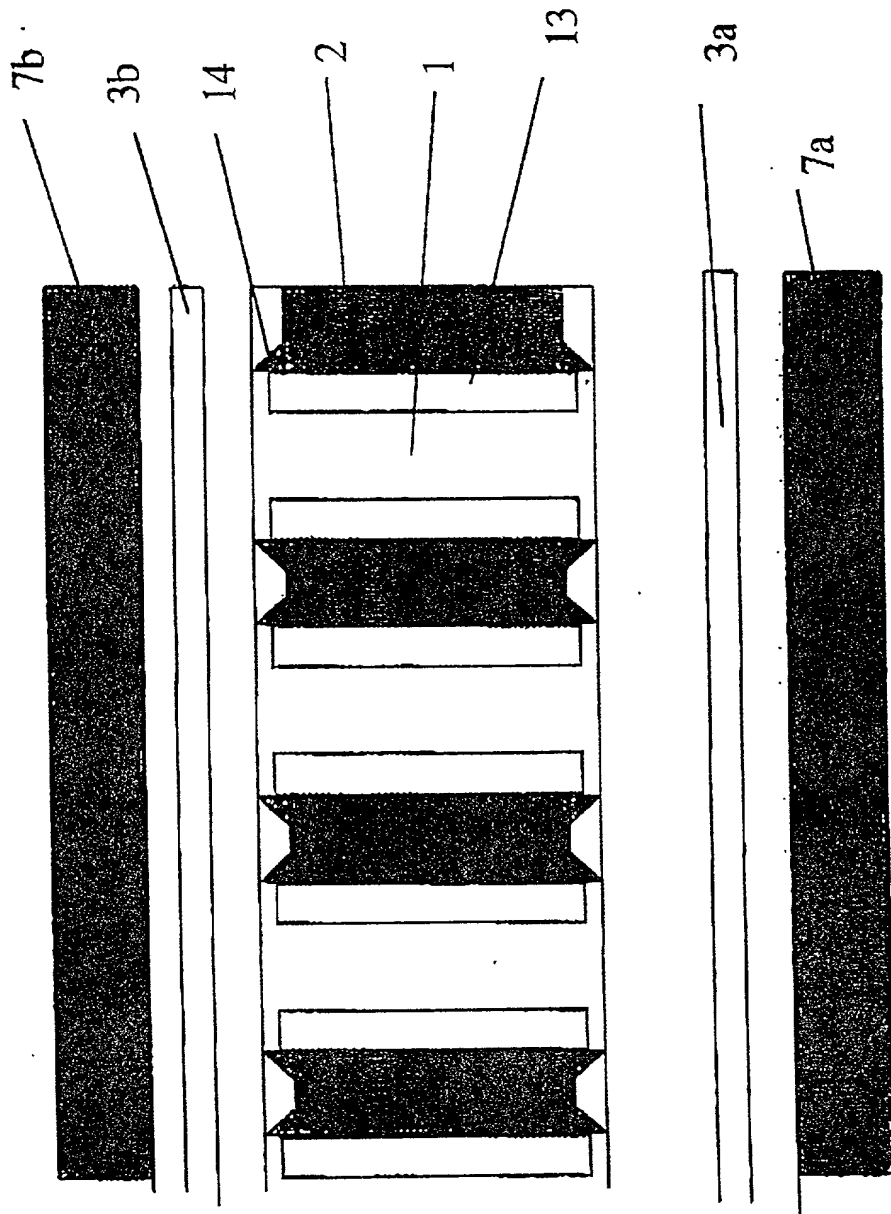


Fig. 4



5/7

Fig 5a



6/7

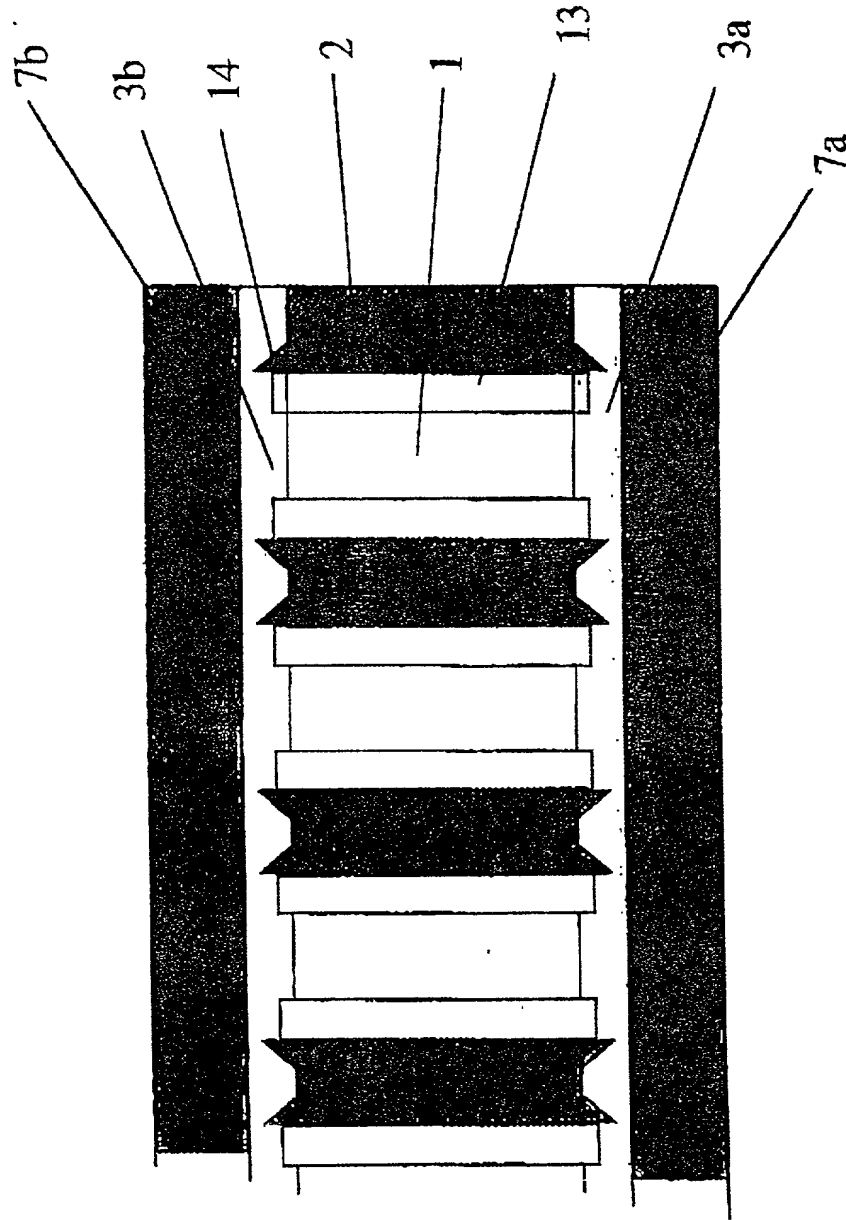
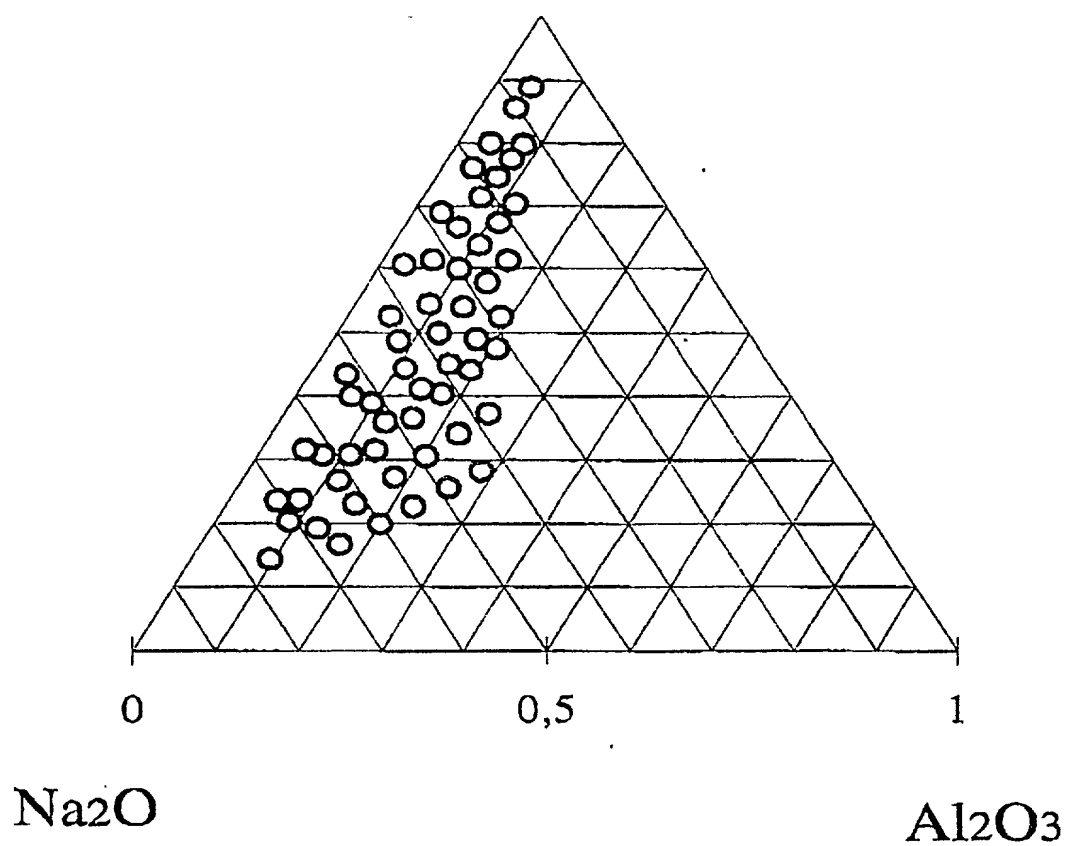


Fig. 5b

SiO₂



Declaration and Power of Attorney for Patent Application

Déclaration et Pouvoirs pour Demande de Brevet

French Language Declaration

En tant qu'inventeur nommé ci-après, je déclare par le présent acte que

Mon domicile, mon adresse postale et ma nationalité sont ceux figurant ci-dessous à côté de mon nom

Je crois être le premier inventeur original et unique (si un seul nom est mentionné ci-dessous), ou l'un des premiers co-inventeurs originaux (si plusieurs noms sont mentionnés ci-dessous) de l'objet revendiqué, pour lequel une demande de brevet a été déposée concernant l'invention intitulée

COPY

et dont la description est fournie ci-joint à moins

☐ ci-joint

☐ a été déposée le _____

sous le numéro de demande des Etats-Unis ou le numéro de demande international PCT

_____ et modifiée le

_____ (le cas échéant)

Je déclare par le présent acte avoir passé en revue et compris le contenu de la description ci-dessus revendications comprises, telles que modifiées par toute modification dont il aura été fait référence ci-dessus

Je reconnais devoir divulguer toute information pertinente à la brevetabilité comme défini dans le Titre 37, § 1.56 du Code fédéral des réglementations

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

ACCURATE SYNCHRONIZATION DEVICE

the specification of which:

☐ is attached hereto.

☒ was filed on 25 SEPTEMBER 1998

as United States Application Number or PCT International Application Number

PCT/EP98/02066 and was amended on

_____ (if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56

French Language Declaration

1-00

| | |
|--|---|
| Nom complet du troisième co-inventeur, le cas échéant Daniel DOLFI June 7, 1999 | Full name of third joint inventor, if any |
| Signature de l'inventeur <i>Daniel Dolfi</i> Date | Third Inventor's signature Date |
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| Nationalité Française FRX | Citizenship |
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2-00

| | |
|--|--|
| Nom complet du quatrième co-inventeur, le cas échéant Paul SERGENT June 7, 1999 | Full name of fourth joint inventor, if any |
| Signature de l'inventeur <i>Paul Sergent</i> Date | Fourth Inventor's signature Date |
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|---|---|
| Nom complet du cinquième co-inventeur, le cas échéant | Full name of fifth joint inventor, if any |
| Signature de l'inventeur Date | Fifth Inventor's signature Date |
| Domicile | Residence |
| Nationalité | Citizenship |
| Adresse Postale | Post Office Address |

| | |
|---|---|
| Nom complet du sixième co-inventeur, le cas échéant | Full name of sixth joint inventor, if any |
| Signature de l'inventeur Date | Sixth Inventor's signature Date |
| Domicile | Residence |
| Nationalité | Citizenship |
| Adresse Postale | Post Office Address |

Fournir les mêmes renseignements et la signature de tout co-inventeur supplémentaire.)

Supply similar information and signature for third and subsequent joint inventors